NanoTHOR: Low-Cost Launch of Nanosatellites to Deep Space

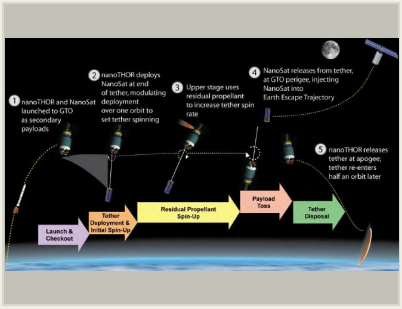
Completed Technology Project (2012 - 2013)

Project Introduction

The NanoTHOR module will enable multiple nanosatellites carried as secondary payloads on upper stages by scavenging orbital momentum and propellant from the discarded upper stage. To enable frequent, low-cost opportunities to deliver nanosatellites to destinations beyond Earth orbit, TUI proposes to develop the "Nanosatellite Tethered High-Orbit Release" (NanoTHOR) module. The NanoTHOR module will enable multiple nanosatellites carried as secondary payloads on upper stages launched into GTO to be injected into Earth-escape trajectories by scavenging orbital momentum and propellant from the upper stage. The NanoTHOR module will utilize a lightweight, re-usable tether to transfer momentum from the rocket stage to the nanosatellite. The use of a rotating tether "multiplies" the rocket's delta-V by the mass ratio of the stage to the nanosat, enabling it to provide both very-high specific impulse propulsion competitive with the best EP thrusters AND short transfer times competitive with chemical rockets. The tether also enables the stage's orbital momentum to be converted to tether rotational momentum to increase the nanosat toss velocity. After completing its mission, the tether can be de-orbited within one orbit period to eliminate collision or debris risks. The nanoTHOR module will provide a low-cost, low-mass means to enable nanosatellites to be launched as ride-share payloads on GEO satellite missions and then delivered to deep-space trajectories. It will therefore enable NASA to affordably launch flotillas of low-cost nanosatellites into heliocentric orbits to conduct searches for NEOs, to study potential targets for manned exploration of asteroids, to provide 'nowcasting' of solar weather conditions, and to serve as communications relays for manned and unmanned missions beyond Earth orbit.

Anticipated Benefits

By scavenging orbital energy from upper stages without any stored energy or propellant requirements, NanoTHOR permits deep-space nanosat missions to launch on rideshare opportunities, enabling NASA and commercial ventures to conduct affordable and frequent missions to explore deep space destinations



Project Image NanoTHOR: Low-Cost Launch of Nanosatellites to Deep Space

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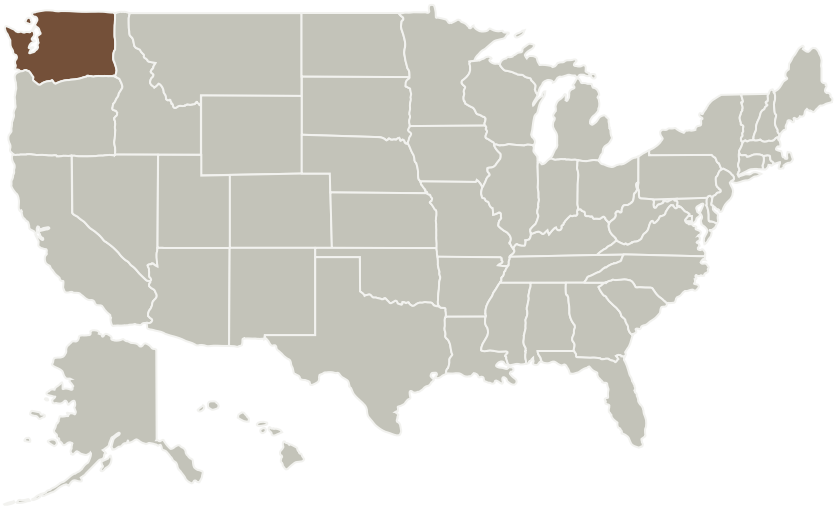
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Tethers Unlimited Inc	Lead Organization	Industry	

Primary U.S. Work Locations
Washington

Project Transitions

September 2012: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Tethers Unlimited Inc

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

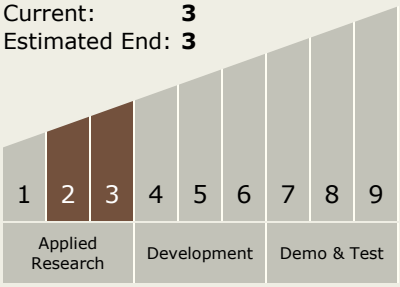
Eric A Eberly

Principal Investigator:

Robert Hoyt

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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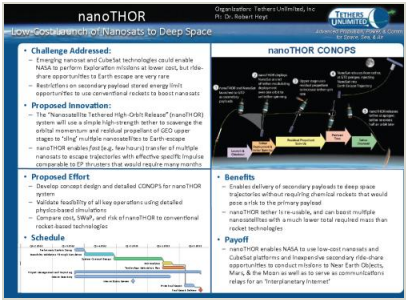
June 2013: Closed out

Closeout Summary: In this Phase I effort, we have investigated the technical f easibility and value proposition for using a simple momentum exchange tether s ystem to scavenge orbital energy from an upper stage in geostationary transfer orbit in order to boost nanosatellites to Earth escape. We developed and simulat ed methods to enable a NanoTHOR module to accomplish rapid transfer of a nan osatellite from a GTO rideshare to an Earth escape trajectory by deploying the n anosat at the end of a long, slender, high-strength tether and then using winchi ng in the Earth's gravity gradient to convert orbital angular momentum into rota tional angular momentum. These simulations demonstrated the feasibility of pro viding delta Vs on the order of 800 m/s with a simple, lowMmass tether system. We developed concept designs to enable the NanoTHOR tether to act as a reusa ble in-space upper stage, boosting multiple nanosatellites on a single launch and doing so with a mass requirement lower than that of conventional rocket technol ogies. Combining the NanoTHOR system to provide EarthMescape injection with a water electrolysis based thruster for maneuvering in heliocentric orbit, we dev eloped a concept for an Asteroid Payload Express service, which enables a 6U C ubeSat to deliver small payloads to Mars orbit, lunar orbit, and rendezvous with at least 110 of the known nearMEarth asteroids. Evaluation of the technology re adiness of the components required for NanoTHOR indicate that the hardware re quired is all mid-TRL, and the lower-TRL controls and integration components ca n be advanced to midMTRL with modest investment. By scavenging orbital ener gy from upper stages without any stored energy or propellant requirements, Na noTHOR permits deep space nanosat missions to launch on rideshare opportuniti es, enabling NASA and commercial ventures to conduct affordable and frequent missions to explore deep space destinations.

Images



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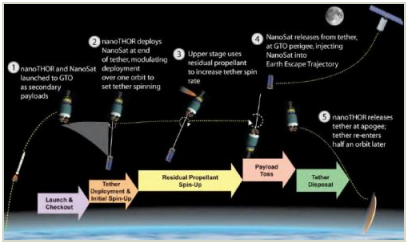
Project Image NanoTHOR: Low-Cost Launch of Nanosatellites to Deep Space
(https://techport.nasa.gov/image/102129)



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Project Image NanoTHOR: Low-Cost Launch of Nanosatellites to Deep Space
(https://techport.nasa.gov/image/102262)

Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.2 Electric Space Propulsion
    - TX01.2.2 Electrostatic

Target Destinations

Others Inside the Solar System, Outside the Solar System